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Design Construction Analysis Feedback

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CEMP-CE

Subject: CRACK CONTROL IN CONCRETE SLABS

Applicability: Information

DISCUSSION: Recently we have experienced excessive shrinkage cracking in Reinforced Rib Mat slabs-on-grade (RRMS). This results in customer dissatisfaction when the facilities are turned over. In order to reduce the presence of shrinkage cracks to acceptable levels, an improved crack control system is required. While this discussion is specifically for (RRMS) foundations, the same rationale can be used to minimize shrinkage cracking for all concrete slabs-on-grade.

DCAF Bulletin 89-22 addressed the subject of cracks in slabs-on-grade and this guidance is still applicable.

Excessive shrinkage cracking in the slabs of ribbed mat foundations has been a persistent problem. This is a result of the volume decrease of the concrete during curing, which is a problem on all concrete flat work with significant lateral dimensions. In a relatively low percentage of ribbed mat foundations moderate to severe cracking has been experienced, especially in vehicular loaded areas where flexural concrete and exposed floors were required. Due to additional lateral restraint imposed by the system of stiffening beams and continuous reinforcing steel, ribbed mat foundations have greater potential for cracking than constant thickness slabs-on-grade. The following guidance is furnished to minimize cracking on the on-grade-slabs for ribbed mat foundation systems.

RRMS shall be placed in 6.1 to 7.6 m (20 to 25 foot) wide lanes using lane placement techniques. For slabs exposed to vehicular traffic, lanes shall have transverse control joints spaced 20 to 30 times the slab thickness. Other slabs shall have control joints with a maximum spacing of 6.1 m (20 feet). It will be necessary to coordinate these joints with the location of the construction joints for maximum efficiency. The depth of the cut remains at 25mm (1 inch) or 1/4 of the slab thickness whichever is greater.

Reinforcing for crack control should be installed between 38mm (1.5 inch) and 64mm (2.5 inches) from the surface of the slab. It must be installed deep enough, however, to not be cut when the crack control joints are sawed. The minimum amount of slab steel reinforcement shall 0.5 %, with a maximum 300 mm (12 inches) spacing each way. Closer spacing of the steel reinforcement does not prevent cracking, however it does assure that, if shrinkage cracking occurs, the cracks will be smaller and tighter. Details of steel reinforcement at columns, re-entrant corners and openings in the slab shall be provided to prevent cracking.

The structural design of vehicular loaded slabs shall be based on a 28 day compressive strength of 28MPa (4.0 ksi). For other slabs a 28 day compressive strength of 21MPa (3.0 ksi) shall be used. To limit the shrinkage potential it is desirable to limit the cement content since having sound concrete of adequate strength without cracks is preferable to over-strength concrete which has cracks (increased cement content increases the heat of hydration and therefore the potential for cracking).

There are certain items of the specifications that require close scrutiny during construction. These items must be emphasized during the Preparatory Quality Control meeting. The following items shall be addressed during this meeting.

a. Specifications should require a mix design that incorporates a 25 mm to 38mm (1.0 to 1.5 inch) coarse aggregate maximum size with an appropriate gradation specification. The mix design should be Government Approved (GA) to assure the mix design is suitable for RRMS. Assure that the approved mix design is used <u>with no deviations</u> from the specification.

b. Assure that the removal of existing insitu material is in accordance with the plans and specifications and that fill material used to replace the existing material is in accordance with the specified plasticity, gradation, and compaction requirements. Also assure that proper drainage is established so that water does not pond in or adjacent to the RRMS. Prior to placement, the area should be inspected for proper fill material, capillary water barrier, vapor barrier, and reinforcing steel.

c. Require placement of the slab at a maximum of 76 mm (3 inches) slump, with a maximum water/cement (w/c) ratio of 0.42. Assure that no water is added to the truck mixer after the design w/c ratio has been reached. Assure that the placement temperature of the concrete is between 10-32 degrees C (50-90 degrees F).

d. Pumping will be allowed provided it can be shown that the proposed pumping does not increase the shrinkage potential.

e. High Range Water Reducing Admixtures (HRWRA), often referred to as Superplasticizers, will be allowed if it is shown that the concrete produced with HRWRA is not subject to increased shrinkage, segregation, and retarding/flash setting. Some labratory data confirms that HRWRA can increase concrete drying shrinkage at a given w/c ratio. Therefore, the reduction of water achieved by using HRWRA is no guarantee that concrete shrinkage will also be reduced. The only way to know if a particular HRWRA will result in lower shrinkage is to test a batch with a particular mix design. If testing shows that the HRWRA proposed does not increase shrinkage, it may be used but its use must be rigidly controlled per Engineering Guidance.

f. Assure that lane placement and weakened plane joints are as shown on the plans. Note that, when sawed joints are used, they must be done upon initial set of the concrete (no raveling), in the shortest time possible, and always not later than 3 hours after placement.

g. New Engineering Guidance will require a moist cured slab for 7 days using wet mats to help control cracking.

Miscellaneous other causes for cracks noted lately in regular slab-on-grade construction are:

a. Not orienting the blocks around columns in a diamond so that the corners of the block coincide with the sawed joints or construction joints running along column lines.

b. Having wire fabric mesh pushed down to the bottom of the concrete instead of per contract requirements; also locating conduit cast in the slab too near the surface.

c. Locating a concrete slab-on-grade so that the edges rest on an edge of the footing below while the remainder of the slab is on the fill causing differential settling and cracking.

In critical slabs where cracking is detrimental to performance (e.g. hazardous material storage) or where no cracking will be acceptable, properly designed shrinkage compensating concrete (using Type K, expansive cement) should be investigated.

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